TEST OF NASA/JPL
INFLATABLE ROVER (Tumbleweed)

Pt. Barrow Alaska

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Nature of test

Field test of Tumbleweed autonomous rover related technology in a relevant extreme environment: Pt. Barrow, Alaska

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Funding

NASA Earth Science (Code Y) & NASA Aerospace Technology (Code R)

Equipment Characteristics

Tumbleweed consists of an electronics package suspended in an inflated ball (bladder); ball is 2 layers, one of nylon and one of polypropylene; total mass less is than 10 kg; 2 m diameter inflated; inflation with air takes 10 minutes; minimum wind for movement is 2 m/s; acquires and transmits GPS/environment data en route via Iridium modem, speed estimated at 5 m/s.

Test Scenario

Test of stability of communication link through Iridium modem and localization of rover by GPS receiver while tumbling in an extreme environment (high latitude, low temperature, ice/snow cover). Secondary tests: Lifetime/Capacity Temperature Issues with several battery technologies (Primary :Alkaline, Lithium, Rechargeable: NiMh), Functionality of Environmental Sensors (Temp, Pressure, Time, Inclination/Acceleration, Battery Monitoring)

Test Results:

The hardware and system testing went very well with all systems performing adequately. The main outcomes were that: the electronics survived at temperatures of < -14C and while the electronics were in the bladder and tumbled for up to 40 minutes at a time the system saw no GPS lock loss, electronics failures, or comm. issues. The electronics within the bladder stabilized at -5C when active. All data was stored on-board in EEPROM and sent back to a ground station periodically.

Each type of test is briefly described below.

Test of stability of communication link through Iridium modem:

Modem tests performed adequately with satellite lock being acquired with ~30 sec. of modem turn on and surviving temperatures of -14C. Data rates are 2.4kpbs in the current configuration. Further tests were preformed to connect from Iridium Modem to Iridium Modem and the system also worked well for that use.

Localization of rover by GPS receiver while tumbling

Tests using a GPS receiver with a single integrated antenna for acquiring and maintaining signals went well with the current unit configuration holding lock during all rolling/tumbling tests. This proves that a unit can be used in a tumbling fashion without requiring the antenna to constantly point up thus reducing the need for this constraint on the tumbleweed system.

Lifetime/Capacity Temperature Issues with several battery technologies (Primary :Alkaline, Lithium, Rechargeable: NiCad, NiMh),

Different Battery Technologies were briefly tested for their temperature characteristics, current output requirements and lifetime issues. The battery types tested were: Alkaline, Photo Lithium, NiCad, and NiMh.

Alkaline (non-rechargeable): Inexpensive, Universally Available, Moderate Current Output, Performance drastically deteriorates with lower temperature. Good for quick turnaround testing.

Photo Lithium (non-rechargeable): High current output, good low temp. characteristics to -40C, lightweight, high power density, higher priced, special order in larger packages (ie. D and DD size). Good candidate for actual deployments

NiCad (rechargeable): Poor low temperature characteristics, moderate power density.

NiMh (rechargeable): Good low temperature characteristics, moderately priced, special order in larger formats. Good for tests where a rechargeable system would lower costs.

Conclusions: A model of lithium cells called the 3B76, in particular, might meet the requirements of a deployment with a total capacity of 30AH, drain rate of 350ma/cell, in a DD format (1.32 in. diameter by 4.39 in long.)

Functionality of Environmental Sensors (Temp, Pressure, Time, Inclination/Acceleration, Battery Monitoring)

Temperature: System worked well and tracked environment temp up to -14C

Pressure: System worked well and tracked environment pressure up to -14C

Time: System worked well and tracked real time up to -14C

Inclination/Acceleration: System worked well and tracked inclination in 2 directions up to -14C

Battery Monitoring: System worked well and tracked battery energy up to -14C

Near Term Enhancements:

1. Migrate the circuit boards from wire-wrap prototype boards to printed circuit boards
2. Integrate Tumbleweed with current Ground Station Display Software
3. Add third axis accelerometer for a complete understanding of rolling motion
4. Incorporate New GPS/Modem combination units
5. Incorporate 2 Imagers unit that will be located at the end of the preferred roll axis
6. Make a total of Two Complete sets of Electronics (1 primary, 1 backup)

Misc. Tweaks:

1. Calibrate Pressure Reading Sensor
2. Calibrate Battery Measurement
3. Calibrate accuracy of real time clock